

EXHIBIT 1

FINAL VERSION

Scheduled for Oral Argument on February 26 and 27, 2001

IN THE
United States Court of Appeals
FOR THE DISTRICT OF COLUMBIA CIRCUIT

Nos. 00-5212, 00-5213

MICROSOFT CORPORATION,
Defendant-Appellant,

—v.—

UNITED STATES OF AMERICA,
Plaintiff-Appellee.

MICROSOFT CORPORATION,
Defendant-Appellant,

—v.—

STATE OF NEW YORK, *ex rel.* Attorney General ELIOT SPITZER, *et al.*,
Plaintiffs-Appellees.

ON APPEAL FROM THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

BRIEF FOR DEFENDANT-APPELLANT

WILLIAM H. NEUKOM
THOMAS W. BURT
DAVID A. HEINER, JR.
MICROSOFT CORPORATION
One Microsoft Way
Redmond, Washington 98052
(425) 936-8080

JOHN L. WARDEN
RICHARD J. UROWSKY
STEVEN L. HOLLEY
RICHARD C. PEPPERMAN, II
SULLIVAN & CROMWELL
125 Broad Street
New York, New York 10004
(212) 558-4000

*Counsel for Defendant-Appellant
Microsoft Corporation*

November 27, 2000

(Additional Counsel Listed on Inside of Cover)

CHARLES F. RULE
FRIED, FRANK, HARRIS, SHRIVER & JACOBSON
1001 Pennsylvania Avenue, N.W.
Washington, D.C. 20004
(202) 639-7000

ROBERT A. LONG, JR.
COVINGTON & BURLING
1201 Pennsylvania Avenue, N.W.
Washington, D.C. 20004
(202) 662-6000

CARTER G. PHILLIPS
SIDLEY & AUSTIN
1722 I Street, N.W.
Washington, D.C. 20006
(202) 736-8000

Following this Court's June 23, 1998 decision in the Consent Decree Case—which rendered plaintiffs' tying claim legally untenable—plaintiffs raised a variety of new allegations, seeking to convert their tightly-focused case into an omnibus Section 2 action. This expansion of the case became apparent in August 1998 when, without amending their complaints, plaintiffs began pursuing in discovery new accusations concerning Microsoft's interactions with Sun, Intel, Apple, RealNetworks and IBM. Over Microsoft's objection, the district court pressed ahead with its plan for a highly-expedited trial, assuring Microsoft that it “would not be making any findings” and “would not predicate any relief” on matters unrelated to the conduct challenged in the complaints, J.A. 380, assurances it would later repudiate.

C. The Rulings Below

Despite Microsoft's motion for a continuance, trial began on October 19, 1998, five months after the complaints were filed. The parties concluded their cases-in-chief on February 26, 1999 and presented rebuttal evidence between June 1 and June 24, 1999.

The district court issued findings of fact on November 5, 1999. 84 F. Supp. 2d 9 (D.D.C. 1999). Although 412 paragraphs long, the district court's findings contain *no* citations to the record, making it impossible to ascertain the purported basis for many findings. The most inculpatory “findings” consist of sweeping, conclusory assertions, unfounded inferences and speculative predictions masquerading as “facts.” *E.g., id.* at 111-12 (FF 411-12). In commenting to the *New York Times* on the harsh tone of his findings, the district judge explained his judicial philosophy towards Microsoft as follows:

I like to tell the story of the North Carolina mule trainer He had a trained mule who could do all kinds of wonderful tricks. One day somebody asked him: “How do you do it? How do you train the mule to do all these amazing things?” “Well,” he answered, “I’ll show you.” He took a 2-by-4 and whopped him upside the head. The mule was reeling and fell to his knees, and the trainer said: “You just have to get his attention.” I hope I’ve got Microsoft’s attention.

First Wave Agreements. The district court found that Microsoft's First Wave agreements required certain ISVs to distribute Microsoft's JVM. 84 F. Supp. 2d at 108-09 (FF 401). The First Wave agreements, however, did not prevent ISVs from making their Java programs compatible with non-Microsoft JVMs or from distributing those other JVMs with their Java programs. J.A. 9995-96.

Intel's Support of Java. According to the district court, Microsoft "pressured" Intel to "abstain from aiding in Sun's" Java development work. 87 F. Supp. 2d at 43. Believing that Sun's Java strategy, if successful, would take customers away from both Microsoft and Intel, Microsoft attempted to convince Intel that supporting Sun's Java plans was contrary to Intel's interest. J.A. 3771-72. There is no evidence that Intel felt compelled to follow Microsoft's advice on this subject or that Intel reduced its support for Java as a result of anything Microsoft said. Indeed, Intel continued to support Java long after the discussions in question occurred. J.A. 3772; *see also* J.A. 5730-31; J.A. 9906.

2. Intel

"Although Intel is engaged principally in the design and manufacture of microprocessors, it also develops some software. Intel's software development efforts . . . are directed primarily at finding useful ways to consume more microprocessor cycles, thereby stimulating demand for advanced Intel microprocessors." 84 F. Supp. 2d at 34 (FF 95). At trial, plaintiffs asserted that Microsoft interfered with Intel's release of Native Signal Processing ("NSP") software in 1995, an allegation that appeared nowhere in their complaints. The initial purpose of NSP software was to enable Intel microprocessors to perform tasks (such as those relating to sound generation) usually performed by separate devices known as "Digital Signal Processors." J.A. 3762. Intel

subsequently expanded its use of the term “NSP” to refer to a package of unrelated software, such as power management software for notebook computers. J.A. 3762.

Microsoft and Intel must work closely together to ensure that their operating systems and microprocessors are compatible. J.A. 3758-59; J.A. 5578-79; J.A. 11579; J.A. 13119-20. In the spring of 1995, Intel first informed Microsoft of its imminent plans to release NSP software, which was designed to run *only* on Windows 3.1 and thus was incompatible with both Windows 95 (then in final stages of testing) and Windows NT (released two years earlier). J.A. 3762-63; J.A. 5588; J.A. 13183-84, 13200, 13204-06. Microsoft expressed concern that Intel’s NSP software would not work with Microsoft’s two 32-bit operating systems. J.A. 3763; J.A. 11582. In response, various Intel executives acknowledged that Intel had made a mistake in developing NSP software for Windows 3.1. J.A. 5585-86; J.A. 13183-84; *see also* J.A. 9904 (“[Dr. Grove] felt bad that the software was focused on Windows 3.1 and not Windows 95 or NT. He says that was a mistake.”).

Along with its concerns about compatibility, “Microsoft also complained that Intel had not subjected its software to sufficient quality-assurance testing. Microsoft was quick to point out that if Windows users detected problems with the software that came pre-installed on their PC systems, they would blame Microsoft or the OEMs, even if fault lay with Intel.” 84 F. Supp. 2d at 35 (FF 99). At Intel’s request, Microsoft agreed to study Intel’s NSP software and provide feedback. J.A. 3763. Microsoft prepared a memorandum entitled “Microsoft NSP Analysis and Recommendation,” which identified more than a dozen major problems with NSP software. J.A. 11677. Intel ultimately decided to discontinue its efforts to promote NSP software for Windows 3.1, and instead work with Microsoft to ensure that NSP software was compatible with Windows 95. J.A. 3765; J.A. 5617; J.A. 13190.

The district court acknowledged that “Microsoft’s concerns with compatibility and quality were genuine,” but found that Microsoft’s primary concern was that “NSP software would render ISVs, device manufacturers, and (ultimately) consumers less dependent on Windows.” 84 F. Supp. 2d at 35 (FF 99). The district court also recognized, however, that “[t]he development of an alternative platform to challenge Windows was not the primary objective of Intel’s NSP efforts.” *Id.* (FF 101); *see also* J.A. 13187. And there is no finding that NSP software had any potential to displace Windows as a platform for applications.

In any event, Microsoft worked with Intel to make NSP software suitable for use with Windows 95 and Windows NT. J.A. 3765; J.A. 5643; J.A. 13190-91, 13200. Although the district court found that Intel later “agreed to stop developing platform-level interfaces that might draw support away from interfaces exposed by Windows,” 84 F. Supp. 2d at 36 (FF 102), the testimony of both Steven McGeady and Ron Whittier of Intel is to the contrary. McGeady admitted that Intel did not change its software development policies after 1995, J.A. 5697-99, and Whittier testified that Intel did not reduce its efforts to develop “platform level software,” J.A. 13192-93.

3. Apple

At trial, plaintiffs challenged two aspects of Microsoft’s relationship with Apple, neither of which was mentioned in their complaints: (i) Microsoft’s discussions with Apple concerning Apple’s QuickTime multimedia software and (ii) a wide-ranging, mutually-beneficial business relationship that Apple and Microsoft entered into in August 1997.

QuickTime. “QuickTime is Apple’s software architecture for creating, editing, publishing, and playing back multimedia content (*e.g.*, audio, video, graphics, and 3-D graphics).” 84 F. Supp. 2d at 36 (FF 104). Apple created QuickTime as a component of Apple’s Mac OS and later

ported QuickTime to Windows and other operating systems. J.A. 3115; J.A. 10488; J.A. 10442-43. Microsoft has included similar multimedia software, now called DirectX, in its operating systems since the release of Windows 3.1 in 1992. J.A. 3555-56. Windows users can access DirectX multimedia content through a user interface called Windows Media Player. J.A. 3557. DirectX also provides a set of system services that ISVs can invoke to obtain multimedia capabilities for their applications. J.A. 3556.

Contrary to plaintiffs' suggestion, Microsoft never told Apple to stop developing QuickTime for Windows. Before Microsoft began talking with Apple about multimedia playback software, Apple sought to persuade Microsoft to abandon DirectX in favor of QuickTime. J.A. 3570-71; J.A. 12175; J.A. 12918-19; J.A. 16962-63, 16965; J.A. 13262-63. Microsoft declined and, starting in 1997, sought to persuade Apple to cooperate in improving DirectX on the ground that having incompatible multimedia playback software on Windows was not in the interests of either company's customers or the industry. J.A. 3550, 3552, 3569; J.A. 12907-08; *see also* 84 F. Supp. 2d at 37 (FF 110); J.A. 3564; J.A. 12921. Microsoft made it clear, however, that such collaboration would not preclude Apple from continuing to develop and market QuickTime for Windows. J.A. 3569-70. For instance, Apple could have built its own user interface on top of the unified multimedia playback software in Windows to compete with Windows Media Player. J.A. 3552-53, 3569-70, 3585.

"The discussions over multimedia playback software culminated in a meeting between executives from Microsoft and Apple executives, including Apple's CEO, Steve Jobs, at Apple's headquarters on June 15, 1998." 84 F. Supp. 2d at 37 (FF 108). At that meeting, Microsoft's Engstrom reviewed with Apple a slide presentation entitled "QuickTime/DirectX Convergence Proposal." J.A. 12177; *see also* J.A. 3579-86. Engstrom again sought Apple's cooperation in

developing unified multimedia playback software for Windows based on DirectX, and Apple again urged Microsoft to abandon DirectX in favor of QuickTime. J.A. 3583; J.A. 5477-78. No consensus was reached, however, because neither company was willing to embrace the other's technology. Although Apple's Jobs "reserved comment during the meeting with the Microsoft representatives," he "explicitly rejected Microsoft's proposal a few weeks later." 84 F. Supp. 2d at 37 (FF 109).

The district court incorrectly found that Microsoft offered to cede to Apple the development of APIs for authoring media content if Apple accepted Microsoft's proposal. 84 F. Supp. 2d at 36 (FF 105). What Microsoft told Apple was that if Apple created authoring APIs targeted at DirectX, Microsoft would not have to invest the resources necessary to do so itself. J.A. 8687-88. Microsoft also made clear that if the two companies did not work together on unified multimedia playback software for Windows, Microsoft would continue developing DirectX on its own, including APIs for authoring multimedia content, because a complete multimedia solution requires both authoring and playback capabilities. J.A. 3578-79.

The August 1997 Agreements. "In 1997, Apple's business was in steep decline, and many doubted that the company would survive much longer." 84 F. Supp. 2d at 94 (FF 344). For several years, Apple had asserted that several Microsoft products, including Windows and Office, infringed 24 Apple patents. J.A. 3782. Microsoft believed that Apple's patent infringement claims were baseless, but nevertheless was concerned that Apple might sue as part of a "go for broke" strategy. J.A. 3782-83. In March 1997, Apple asserted that Microsoft should pay Apple \$1.255 billion for a patent cross-license, J.A. 5379-83; J.A. 10001, an amount approximately equal to Apple's total net worth at the time, J.A. 3783.

Throughout the spring and early summer of 1997, Apple and Microsoft unsuccessfully attempted to resolve their patent dispute. J.A. 3783-84. Microsoft informed Apple that if Apple filed an infringement action seeking a billion dollars in damages, Microsoft could not deal with Apple on a “business as usual” basis, and might cease developing Office for the Macintosh. J.A. 3784; J.A. 9911. Wholly apart from this patent dispute, Microsoft saw little business justification for continuing to develop Office for the Macintosh when the developers involved could be more profitably deployed on Office for Windows. J.A. 3787-88; J.A. 12465. In fact, “[o]bserving Apple’s poor performance in the marketplace and its dismal prospects for the future, many ISVs questioned the wisdom of continuing to spend time and money developing applications for the Mac OS.” 84 F. Supp. 2d at 94 (FF 344).

On July 9, 1997, Steve Jobs replaced Gil Amelio as Apple’s CEO. J.A. 3784-85. Apple and Microsoft thereafter quickly hammered out three interrelated agreements, announced on August 7, 1997, that resolved a variety of open issues. J.A. 3784-85, 3788, 3790-91; J.A. 12464. Pursuant to a patent cross-license (J.A. 9951), Microsoft paid Apple \$93 million for the right to use Apple’s patents. J.A. 16001. Pursuant to an investment agreement (J.A. 9913), Microsoft purchased \$150 million of non-voting Apple preferred stock, providing Apple with a much-needed capital infusion. J.A. 3788, 3789. And, pursuant to a technology agreement (J.A. 10116), Microsoft agreed to develop the same number of major versions of Office for the Macintosh as it developed for Windows over the next five years, and Apple agreed to make IE for the Macintosh the default Web browsing software for the Mac OS for the same period as long as that version of IE remained “competitive” with other Web browsers. J.A. 3789-90; J.A. 10119-21. Apple reserved the right, however, to “bundle browsers other than Internet Explorer” with the Mac OS, and, in fact, bundles both IE and Navigator with the Mac OS today. J.A. 10119; *see also*

J.A. 3789-90. (IE for the Macintosh was designed, developed and tested from the ground up as Macintosh software, and thus is very different from the components of Windows also referred to by the “IE” brand name. *See* J.A. 4465-66; J.A. 3791-92.)

The district court found that Microsoft “requir[ed] Navigator’s exclusion from the default installation for the Mac OS 8.5 upgrade.” 84 F. Supp. 2d at 97 (FF 356). The technology agreement required, however, only that Navigator or any other Web browsing software be included in “folders” in the Mac OS like the OLS folder in Windows. J.A. 10119-20. Moreover, contrary to the district court’s suggestion that Apple’s “browsing software” obligation was the quid pro quo for Microsoft’s Mac Office obligation, 84 F. Supp. 2d at 96 (FF 354), Apple’s Avie Tevanian testified that *all* of the various obligations (the patent cross-license, Microsoft’s investment and the technology agreement) were part of one “overall agreement” between the two companies, J.A. 5402-03.

4. RealNetworks

Plaintiffs contended at trial that Microsoft attempted to persuade RealNetworks—a company not even mentioned in their complaints—not to compete with Microsoft in developing playback software for streaming audio and video content. Unlike other types of multimedia content, streaming media content is viewable before an entire file is downloaded from the Internet, simulating “live” broadcasting. J.A. 3555; J.A. 3871. Although Microsoft had been developing streaming media playback software for several years, it had fallen behind other companies, particularly RealNetworks. J.A. 3872. This led Microsoft to acquire VXTreme in 1997 to obtain their streaming media technology and developers with expertise in that area. J.A. 3872.

Shortly thereafter, RealNetworks approached Microsoft to discuss the creation of what RealNetworks described as a “fundamental relationship” between the companies. J.A. 7699-7700; J.A. 10366-67. Microsoft agreed with RealNetworks to (i) make a non-voting equity investment in RealNetworks, (ii) license RealNetworks’ streaming media playback software for inclusion in Windows 95, and (iii) cooperate in developing a common file format for streaming media content. J.A. 3873; J.A. 16613. The agreements did not inhibit RealNetworks from continuing to develop streaming media playback software for Windows. J.A. 3874; J.A. 7700-02.

Not long after the agreements were signed, RealNetworks manifested an intention not to comply with its obligations, refusing to work with Microsoft to create a standard file format for streaming media. J.A. 3876-77. In fact, Microsoft’s Bob Muglia described RealNetworks’ conduct at the time as “a full-scale, anti-Microsoft assault.” J.A. 12568. In any case, Microsoft’s agreements with RealNetworks had no market impact: RealNetworks remains the clear usage share leader in streaming media playback software, both on Windows and on other platforms. J.A. 3558-59; J.A. 12836; *see also* 84 F. Supp. 2d at 38 (FF 114).

5. IBM

On the one issue relevant to plaintiffs’ complaints—distribution of Navigator—IBM’s Garry Norris testified that IBM began preinstalling Navigator on its computers in 1996 and continues to do so today. J.A. 9227. At trial, however, plaintiffs advanced many contentions about Microsoft’s dealings with IBM that were unrelated to the claims asserted in their complaints. For example, they contended that Microsoft treated IBM less favorably than it did other OEMs—particularly Compaq—because IBM marketed products that compete with Microsoft products. In fact, Compaq had the lowest royalty for Windows 95 of any OEM both because it shipped a higher volume of Microsoft’s operating systems and because it helped

develop plug-and-play technologies, an important new feature of Windows 95. J.A. 4001, 4003-04; J.A. 9026-27; J.A. 13425; J.A. 13503. By contrast, IBM—which was promoting its own operating system, OS/2, at the time—did nothing to help Microsoft develop Windows 95, and thus paid a somewhat higher royalty for it. J.A. 9031-32. Microsoft offered IBM a “Frontline Partnership” similar to Microsoft’s arrangement with Compaq, but IBM declined, opting instead to pursue its “IBM First” initiative. 84 F. Supp. 2d at 39 (FF 117, 119); *see also* J.A. 4003-04; J.A. 13433-34.

The district court suggested that Microsoft did not grant IBM a Windows 95 license until the operating system’s launch date because IBM previously had announced its intention to pre-install SmartSuite, a suite of business productivity applications that competes with Microsoft Office, on new IBM computers. 84 F. Supp. 2d at 40-41 (FF 122-25). Yet IBM’s Norris disavowed any connection between IBM’s SmartSuite announcement and the subsequent impasse in negotiations over a Windows 95 license. J.A. 9129-30. The impasse instead arose because an ongoing audit of IBM’s royalty payments to Microsoft had revealed substantial underpayments by IBM. J.A. 13485; J.A. 13487. Although Microsoft estimated that IBM owed it more than \$50 million, J.A. 9134; J.A. 10663, Microsoft agreed to settle the audit for \$31 million, J.A. 13490. IBM and Microsoft signed a Windows 95 license agreement the same day they settled the audit—the Windows 95 launch date. J.A. 8996-97; J.A. 9172. The district court found that “IBM never agreed to renounce SmartSuite or to increase its support for Microsoft software.” 84 F. Supp. 2d at 41 (FF 125).

The district court also found that Microsoft withheld technical and marketing support from IBM that other OEMs received. *Id.* at 39 (FF 116). For example, the district court noted that Microsoft in August 1996 refused to provide IBM with quotations endorsing IBM PCs for

organizations he surveyed (nearly all of which used Navigator) complained that Windows 98 invokes IE instead of Navigator in those isolated circumstances. J.A. 5938.

No Distribution Foreclosure. There is no finding that the inclusion of IE in Windows prevented Netscape from getting Navigator into the hands of consumers. *See Roy B. Taylor Sales, Inc. v. Hollymatic Corp.*, 28 F.3d 1379, 1383 (5th Cir. 1994) (“Where, however, only dealers are subject to a tie, competitors do not lose a segment of the tied market if there are genuine available paths to consumers”) (footnote omitted). To the contrary, the district court concluded that Microsoft did not “deprive Netscape of the ability to have access to *every PC user worldwide* to offer an opportunity to install Navigator.” 87 F. Supp. 2d at 53 (emphasis added). Given Netscape’s ability to distribute vast quantities of Navigator—160 million copies in 1998 alone, *id.*—the alleged tie resulted in no injury to competition.

II.

Microsoft Did Not Maintain a Monopoly Through Anticompetitive Conduct.

The district court held that Microsoft maintained a monopoly in “Intel-compatible PC operating systems” in violation of Section 2. 87 F. Supp. 2d at 35-44. That offense has two elements: “(1) the possession of monopoly power in the relevant market and (2) the willful acquisition or maintenance of that power as distinguished from growth or development as a consequence of a superior product, business acumen, or historic accident.” *United States v. Grinnell Corp.*, 384 U.S. 563, 570-71 (1966). Because “[i]t is sometimes difficult to distinguish robust competition from conduct with long-term anticompetitive effects,” *Spectrum Sports, Inc. v. McQuillan*, 506 U.S. 447, 458-59 (1993), Section 2 “must be used with the greatest caution,” *Ball Mem’l Hosp., Inc. v. Mut. Hosp. Ins., Inc.*, 784 F.2d 1325, 1338 (7th Cir. 1986).

Plaintiffs’ monopoly maintenance claim fails for three independently sufficient reasons: (i) Microsoft does not possess monopoly power; (ii) Microsoft did not engage in “anticompe-

titive” conduct within the meaning of Section 2; and (iii) the conduct held to be anticompetitive did not contribute significantly to the maintenance of a monopoly.

A. Microsoft Does Not Possess “Monopoly Power” in a Properly Defined Product Market.

“Monopoly power is the power to control prices or exclude competition.” *United States v. E.I. du Pont de Nemours & Co.*, 351 U.S. 377, 391 (1956). Microsoft does not possess such power in any relevant antitrust market.

1. The Relevant Product Market Is Not Restricted to “Intel-Compatible PC Operating Systems.”

The district court concluded that the relevant product market is limited to “Intel-compatible PC operating systems.” 87 F. Supp. 2d at 36. That “market” is far too narrow because it excludes the most serious competitive threats faced by Microsoft’s operating systems, including the very competitive threats that gave rise to this action. Indeed, the district court’s market definition is so narrow that it excludes Apple’s Mac OS, which has competed with Windows for years, simply because the Mac OS runs on a different microprocessor.

There are two methods of assessing monopoly power: (i) the structural approach, which analyzes the respective shares of firms within a notional “market,” and (ii) the behavioral approach, which examines the defendant’s pricing, output and rate of innovation. J.A. 4282. By adhering rigidly to the structural approach and failing to take into account the dynamism of the software industry, the district court elevated form over substance, excluding from consideration competitive forces that actively constrain Microsoft’s conduct. As a result, the district court’s narrow market definition obscures, rather than illuminates, the underlying competitive reality of the software business.

The behavioral approach is particularly appropriate here given the “dynamic, vigorous competition” in the industry. 84 F. Supp. 2d at 25 (FF 59). Because software is highly malleable,

“market” boundaries are inherently blurry and fluid, and consumer demand for various functionality can be satisfied in different ways. J.A. 4283-84. Many software products, including operating systems, have absorbed other products over time as the underlying microprocessor became more powerful, and each software category leader is threatened from many different directions—from new entrants, from existing niche players that improve their products and from technological advances that render entire categories obsolete or much less important. J.A. 4283-84. The district court found that “[w]hat eventually displaces the leader is often not competition from another product within the same software category, but rather a technological advance that renders the boundaries defining the category obsolete.” 84 F. Supp. 2d at 25-26 (FF 59). Notwithstanding this finding, the district court analyzed competition in static terms, focusing on the narrowest possible definition of the putative market. *E.g., id.* at 26 (FF 60).

a. The District Court’s Market Definition Excludes the Most Serious Competitive Threats to Windows.

The district court’s narrow market definition excludes the very technologies that it found to be the most serious competitive threats to Windows and the targets of the alleged anticompetitive conduct in this case: Navigator and Java. 84 F. Supp. 2d at 28-30 (FF 68-78). “Operating systems are not the only software programs that expose APIs to application developers. Netscape’s Web browser and Sun Microsystems, Inc.’s Java class libraries are examples of non-operating system software that do likewise.” *Id.* at 17 (FF 28). In exposing APIs, such middleware can serve as a platform for applications, supplying functionality otherwise provided by Windows. J.A. 3728-29. To the extent applications rely on middleware to obtain needed functionality, the underlying operating system becomes less valuable. 84 F. Supp. 2d at 17-18 (FF 29). Over time, middleware could extend “downward” to the hardware, assuming more and more operating system functions and thereby rendering the operating system unnecessary.